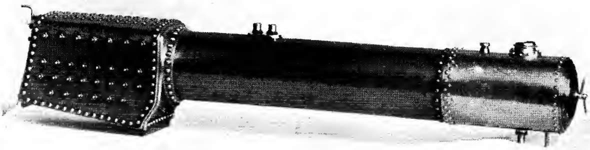
Loco. Coal

THE MODEL ENGINEER

Vol. 81 No. 2011 • THURS., NOV. 23, 1939 • SIXPENCE

In this issue

A $\frac{1}{2}$-in. scale locomotive boiler made by Mr. G. T. Bainbridge, of Enfield, to specification by "L.B.S.C." and drawing No. UM/3 supplied by our Publishing Department. It has successfully withstood a test pressure of 250 lb. per sq. in. left on for 24 hours.



THE MODEL ENGINEER

Vol. 81 No. 2011 November 23rd, 1939

60 Kingsway, London, W.C.2

Editorial Comments

Simple Photographic Enlargers

ELSEWHERE in this issue will be found some practical instructions, by "Kinemette," for the home construction of simple apparatus for enlarging photographs. The outlay required is not great, and the work involved in the construction of the apparatus should afford a welcome and congenial change in the normal routine of the home workshop. The apparatus, when it is finished, can be the means of giving unalloyed pleasure to amateur photographers who may never have essayed the art of enlarging their small photographs. There is an extraordinary fascination, not only in the process but in the finished enlargement which, in ninety-nine per cent. of the pictures, shows details and beauties that the contact-prints fail to reveal. Although miniature cameras are, by far, the most popular among amateur photographers to-day, the large print is still as satisfying as ever. Moreover, after a little practice, a more perfect control of the actual printing through an enlarger is possible than in the case of direct contact-printing from a small negative. Therefore, the time, energy and money expended in making an enlarger are soon amply repaid, in more ways than one. A more lucrative occupation for these "blackout" nights would be difficult to find; and, when the apparatus is in use, a little forethought will easily prevent the enthusiast exceeding the electric light ration.

* * *

The Engineer on Model Making

OUR distinguished contemporary, *The Engineer*, recently published a very kind appreciation of our 2,000th number. It said:—" We desire to offer our hearty congratulations to THE MODEL ENGINEER on the appearance of its two thousandth number and the special issue which celebrates that event. 'The spread of model engineering has been remarkable,' says the Editor. 'The handful of enthusiasts who formed the first readers of THE MODEL ENGINEER have grown into a community of many thousands living in all parts of the world, all animated by an intense love of engineering in one or other of its many branches, and by a desire to reproduce in miniature a prototype which has aroused their admiration, or to give practical shape to designs which emanate from their own practical instincts.' All that is perfectly true. The love of model making is inherent in man, and the spread of technical knowledge, of handicraft, and the cheapening of machines for the model workshop have all helped to foster it. Model making keeps pace with its prototypes; the aeroplane and the speedboat have not encroached upon the territory of the locomotive, the steam engine, and the steamship, but have only added to the number of model makers. When the brothers Marshall laid the foundation of THE MODEL ENGINEER forty years ago, they could not have foreseen what the future held in store, but that they built wisely and well is made evident by the continued prosperity of a little paper which is known, respected, and, let us add, loved by all the engineers of the miniature all over the world." The Editor of *The Engineer* has always extended a very friendly and understanding recognition of the work we have been doing through the pages of the "M.E." Our Exhibitions have invariably received valuable publicity in his columns, and whenever we have found it desirable to consult him for information or assistance in problems or records in which our readers have been interested, his sympathetic co-operation has been freely given. For this encouragement from a contemporary of such high standing in the engineering profession we are very grateful.

* * *

A "Great Eastern" Model

READERS interested in ship modelling will welcome the addition of a scale model of the famous steamship *Great Eastern* to the shipping gallery of the Public Museums at Liverpool. This is due to the generosity of Messrs. Lewis's, Ltd., and the model was formally presented to the Museum on October 31st by Lord Woolton, the Chairman of the Directors of the Company.

Percival Marshall

Calculating Change-Wheels

By J. Bradbury Winter

MODEL engineers do not every day require to use the screw-cutting mechanism of their lathes, so that when the necessity does arise they may not have at their finger tips the method of calculating the gears.

Here are two simple rules which make the operation so easy and rapid that, perhaps, even experienced workers may be surprised.

Small, inexpensive lathes are usually supplied with only a half set of change-wheels, which naturally reduces the number of different threads which are within the range of the machine. The leadscrew on such a lathe has, as a rule, eight threads per inch, and the half set of wheels include the following: 20, 20, 25, 30, 35, 40, 45, 50, 55, 60 and 65. My remarks are based on a lathe of this type, but can be easily modified or extended to fit other types.

There are three essential positions for the wheels, the mandrel, the leadscrew and the stud in the slotted rocker arm.

In simple gearing, only two essential wheels have to be found; the smaller goes on the mandrel, the larger on the leadscrew. They will not be large enough to mesh together, and it is, therefore, necessary to insert an idle wheel (or, in some lathes, two idle wheels) between them, which may be of any convenient size, and mounted on the stud (or studs).

Simple gearing is used for comparatively coarse threads; any threads finer than 26 per inch necessitate compound gearing, which requires four essential wheels.

Rule 1—Simple Gearing

Multiply the thread required and also the leadscrew thread by 5; the results will be the wheels to be used.

Thus, to cut 12 t.p.i., $12 \times 5 = 60$, and $8 \times 5 = 40$; the wheels will be 40 on the mandrel and 60 on the leadscrew.

But with our small set of wheels, we soon get beyond their range; thus, to cut 18 t.p.i., $18 \times 5 = 90$, and $8 \times 5 = 40$. If we had a wheel with 90 teeth, all would be well, but not having it we divide both the results by 2, giving 45 and 20 as our two wheels.

The limit of simple gearing will be reached at 26 t.p.i. $26 \times 5 = 130$ and $8 \times 5 = 40$; dividing both by 2 we get 65 and 20 for our wheels, and as we have no wheel larger than 65 we have reached the limit.

To cut threads finer than 26, we must employ compound gearing. Instead of an idle wheel on the stud, we shall now have two wheels side by side and keyed together.

As before, the wheel on the mandrel will gear with one of these, but instead of this wheel gearing direct with the wheel on the leadscrew the smaller wheel on the stud will now gear with it.

Rule 2—Compound Gearing

Divide the required thread by either 2 or 3, so as to bring it within the range covered by Rule 1.

Applying Rule 1, we obtain the first pair of wheels, the smaller going on the mandrel, the larger on the stud.

The second pair may be any wheels having a ratio of 1:2 if you began by dividing by 2, or 1:3 if you began by dividing by 3.

Example. To cut 40 t.p.i. According to Rule 2, divide 40 by 2 = 20. Applying Rule 1, $20 \times 5 = 100$ and $8 \times 5 = 40$. As we have no wheel of 100 teeth, divide both by 2, and our first pair will be 50 and 20.

As we began by dividing by 2, our second pair must have a ratio of 1:2, say 30 and 60. The 30 will be keyed on the stud alongside the 50, and the 60 will go on the leadscrew.

The finest thread possible with our half set of wheels will be 78. By Rule 2, divide 78 by 3 = 26. By Rule 1, $26 \times 5 = 130$ and $8 \times 5 = 40$. Dividing by 2, our first pair will be 65 and 20. As we began by dividing by 3, our second pair must be in the ratio of 1:3, that is to say 20 and 60.

Even with a full standard set, there are plenty of awkward numbers, like 37, which cannot be cut; but who wants to?

With our reduced set, there are many impossible numbers. We have given 12 as an example of Rule 1, and 13 can be calculated in the same way. But with this exception, only *even* numbers are amenable to Rule 1. (Threads coarser than 12 present technical difficulties for beginners and are, therefore, ruled out.)

When employing compound gearing, Rule 2 will only apply to numbers divisible by 4 between 28 and 52, and only if divisible by 6 between 54 and 78. There is, moreover, one black sheep amongst even this select company; 72 is the culprit. Applying Rule 2, 72 divided by 3 = 24. By Rule 1, $24 \times 5 = 120$ and $8 \times 5 = 40$. Dividing both by 2, we get 60 and 20 for our first pair. Our second pair must have a ratio of 1:3, and would, therefore, be 20 and 60. But we have already used the 60 wheel in our first pair.

Hence it comes about that we can cut no thread between 66 and 78.

These rules are intended to give a quick and easy method of finding the wheels. I do not say that it is impossible to cut any thread not covered by the rules; almost certainly there are one or two, such as 25 and 42, which can be arrived at by juggling with the figures.

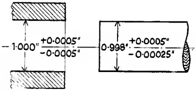
*Gauges and Gauging

A series of great value to engineers of all classes, particularly those who are engaged upon National service

By R. Barnard Way

IN our first article we dealt with the subject of the line Standards upon which all measurements of length are based. Every instrument or tool constructed to make fine measurements can claim one of these original standard bars as its ancestor, for the making of fine tools or machinery of any sort requires an elaborate equipment of accurately-made gauges. The makers of these gauges have their own standard bars, and at least one master bar engraved from the national standard bar direct.

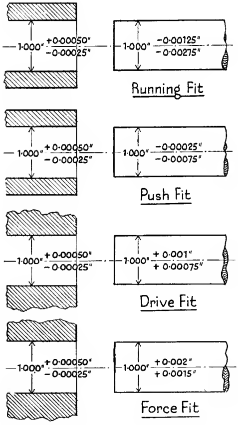
The manufacturer who has decided to instal a complete system of gauging in his shop must first decide what limits are necessary in the production of his manufactures. There is no doubt that the system will cut out a great deal of waste in the form of spoiled work, it does not depend to anything like the same extent upon the judgment of the individual workman. It needs the most skilful mechanic to turn out a large number of parts, all exactly similar, and guaranteed to pair up with other parts made by another man, unless a proper gauging system is available. A much less skilful man can do the same work, in shorter time, with an equipment of gauges. We are all in favour of the highly skilled man, but it must be admitted that there are not so many of them available as there were, and far too few in such days as these. Machinery is more and more intricate than ever, and its manufacture by only partly skilled men is a tribute to the system that has made it possible.



Deciding upon the Limits.

It must be said that the idea of interchangeability can be carried too far, for under certain conditions such a scheme is completely unnecessary. By all means make parts for assembly to reasonable working limits, so as to make that assembly easy, with the positive assurance that they will work correctly when put together. But unless replacement of worn parts is likely to occur, the extreme limit is not needed. During the 1914-18 years, much energy and expense was incurred in the making of ammunition and projectiles to much closer limits than was really essential. Fuses were made with their working parts on a basis of fine limits, but nobody could suggest that replacement of those parts was going to be likely. Again, in such circumstances as the armament industry deals with, different parts for the same assembly may be made in different workshops, possibly on different machines. Here we must expect that a good deal of stringency in the specification, not only as to material but manufacturing methods, must be insisted upon, though so long as the finished parts will pass the same gauges it hardly matters on what machines or by what processes they were made. The gauges used and the methods of gauging must be the same, that is all.

Articles made for destruction need no replacement; other articles that are intrinsically cheap, such as the simple tumbler switches or other domestic electrical goods, need no replacement parts, because it is no matter of expense in replacing the whole article if it fails. It is when we consider machinery of a more expensive nature that it becomes necessary to go into the



The four types of fit and the limits imposed.

*Continued from page 530, "M.E.," November 9, 1939.

matter a little deeper. We are going to do that.

The simplest and most usual way to begin a study of the subject is to consider the fitting of a spindle or plug into a round hole. Quite obviously, the simplest example is a 1″ plug in a 1″ hole, so that will do for us.

There are, at least, four ways of fitting the two together, these are known as the classes of fit, and for one of them there are three sub-classes. Here they are:—

(1) *The Running Fit.*

X is for engine shafts, easy fits, shafts running in several bearings, or one extra long bearing.

Y is for shafts for high speeds.

Z is for fine tool work, sliding shafts.

(2) *The Push Fit.*

The plug can be pushed in by hand, and will rotate without seizing at a slow rate. It is used when the plug has to be secured by key or pin.

(3) *The Driving Fit.*

The plug must be driven in with a hammer or a light press. It cannot be turned round.

(4) *The Force Fit.*

A hydraulic press or shrinking after heating is necessary to get the parts together.

Each one of these fits demands a different set of gauges for its making. You must decide first whether the hole or the plug is to be the standard, that is, which is to be finished to a fixed size. It is usual to make the hole the standard.

Now, however accurately the workman does his part, there is always a degree of error, and this degree of error can be tolerated so long as it does not go too far. There are three expressions in general use in this work that must be clearly understood before we go further:—

Allowance is the clearance between plug and hole to permit the various classes of fit, or to provide for lubrication.

Limit expresses the amount of tolerance that can be allowed in the finished dimension. Thus, our spindle or plug may be 1.001″ or 0.999″ in finished diameter, better expressed as 1″ $\pm$ 0.001″. In such a case the limit is 0.001″.

Tolerance is the total difference between the maximum and minimum sizes permitted; in the case just quoted it is 0.002″.

Observe that the upper and lower limits need not necessarily be the same, for our plug or hole may have an upper limit of 0.0005″ and a lower limit of 0.00025″, giving a tolerance of 0.00075″. It is meaningless to speak of a limit of 0.001″, as this gives no information as to whether it is + or −; the correct form is $\pm$ 0.001″. It is in order to speak of an upper or lower limit, as this is understood to mean plus or minus.

Our figures are taken from the tables published many years ago by the Newall Engineering Company; these still stand, as ever, all over the world.

Before proceeding with the series, here is an example to show how to fix the limits. The hole is reamed out with a 1″ reamer, which, if it is new, may cut oversize by 0.0005″, or, if part worn may cut undersize by the same amount. So, in consequence, we have to be prepared to accept a hole that is 1″ $\pm$ 0.0005″.

To set the limits for the spindle, the allowance must be subtracted from the normal bore of the hole. Supposing the tolerance to be 0.001″, the allowance will be 0.002″, then the spindle diameter will be 0.998″, and we can apply the same limits as the hole, making the dimension as 0.998″ $\pm$ 0.0005″.

A little consideration will show that we can have a hole as large as 1.0005″ diameter, and a spindle as small as 0.9975″; these two, when mated, give an allowance of 0.003″. On the other hand, we can also have a hole as small as 0.9995″ and a spindle as large as 0.9985″, the allowance is then 0.001″. There is thus no possibility of a spindle turning up to mate with a hole of equal size, if we were requiring a push fit, that would be all in order as we shall see.

Now to pass on to the fitting of the four classes of spindle or plug to their holes; we can first consider the running fit. The hole having been made the standard, with a limit of $\frac{+\ 0.0005''}{-\ 0.00025''}$ in every case, we have simply to adjust the plug to it. For class X work, the high limit is given as − 0.00125″, and the low limit − 0.00275″, thus the tolerance is 0.00150″. Observe that the spindle must not be 1″ in diameter, even though the dimension on the drawing would appear to mark it so, showing it as $1.000'' \frac{-\ 0.00125''}{-\ 0.00275''}$ This is obviously the easiest way to indicate it, though it would be possible to show it as 1.002″ $\pm$ 0.00075″.

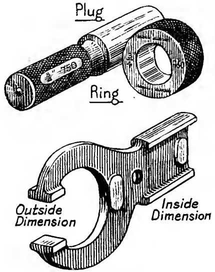
From a large batch of finished pieces made to these dimensions, what can we pick out? The smallest hole passed for use is 1.000″ − 0.00025″ = 0.99975″, and the largest spindle 0.99875″, allowance here is thus 0.001″. The largest hole is 1.0005″ and the smallest spindle 0.99725″, giving a clearance of 0.00325″. There would be a good deal of difference between the performances of the two assemblies quoted, but both would approximate to the tolerance standard.

In the case of the push fit, the normal desired allows for no difference at all between the plug and the hole—which certainly answers the old question in the shops as to whether a 1″ plug will go into a 1″ hole without forcing it. The smallest hole and the largest plug in this case are both to be 0.99975″ diameter. Conversely, the largest hole and the smallest plug may differ by 0.00125″. The sketch, which in each case indicates the customary drawing office method of passing on the instructions, shows the details.

For a driving fit, the plug has got to be larger than the hole, so both upper and lower limit in respect of this part have a + sign, the tolerance is 0.00025″, which means that, on the average, the hole must be by that much smaller than the plug.

The largest plug will be 0.0005″ larger than the largest hole, and 0.00125″ larger than the smallest hole, so there will be a considerable difference in the effort required to drive them together.

Lastly, we have the force fit, where the conditions as to the limits are obviously the same as for the driving fit—only more so! The upper limit for the plug makes it two thou.'s more in diameter than the standard inch, but the smallest plug that can be passed is still 0.001″ larger than the largest hole. On the other hand, the largest



A simple plug and ring, with a horseshoe non-limit gauge.

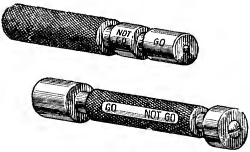
plug and the smallest hole will show a difference of 0.00225″.

The jobs we have quoted here first are about the simplest possible introduction to the study of gauging. With the methods of production of the parts we are not concerned, but it will be necessary to look into the subject of the gauges employed to view them. At first, the simplest types of plug and ring gauges were employed for this purpose, and no doubt there are still plenty such in use. The Limit Gauge is the proper type to employ for work such as we have described so far, because it makes the complete decision as to whether the piece can be passed or rejected. The plug and ring gauge leave a certain amount of the decision to the examiner, if the plug goes into the ring all right, but he must judge the degree of slackness that can be allowed. The Horseshoe Gauge is still seen often enough; this is a double-ended combination tool, illustrated here; one end is formed part-cylindrically for testing internal, and the other one is open for the external measurements.

There must be two gauges, in the same way, for limit gauging, one for internal and one for external testing. Each may be double-ended, the ends being carefully ground to fine limits, actually to the limits specified on the drawings. An illustration of a pair of such gauges is shown here —one illustration, as the Chinese say, being worth a thousand words. The horseshoe type has the openings of its jaws ground and lapped to the two dimensions permitted; for example, consider our running fit spindle and bearing hole, here the limits for the spindle are − 0.00125″ and − 0.00275″. These give the two outside dimensions as 0.99875″ and 0.99725″. One of the jaws of the gauge will be ground to an opening equal to the larger of these two sizes, and this side will be marked " Go." Thus, any piece that will go into these jaws is not in excess of the upper limit, though, of course, a piece that was altogether too small would be passed by it. To guard against this possibility the other jaws are ground to a size just barely lower than the smaller dimension, and this will be marked " Not Go." Any piece that does go into these jaws is too small and must be rejected, just as any piece that will not go into the larger jaws must also be thrown out.

It must be emphasised that it is the gauge that must go, or not go, on to the work, and not the work into the gauge. Understanding of this will, perhaps, make it clearer to the inquirer how such a system infallibly throws out undersize work, for obviously all pieces that are too small will go into both sets of jaws. So long as you understand that if the " not go " jaws *will* go on to the piece then it is too small and is to be rejected. We have found this to be the main stumbling block in explaining the system in the works and elsewhere.

For testing the hole in which the spindle is to run, the limit gauge consists of two plugs formed at either end of a handle. Conversely to the jaw



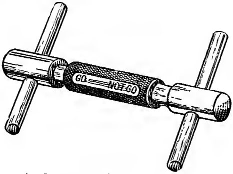
Limit plug gauges.

gauge, the " go " portion is ground to the smaller of the two sizes, so that if a piece will pass this gauge then the bore is not too small. The opposite, or " not go," end will be ground to a size just in excess of the upper limit. If this end will pass into the bore of any piece, then that piece must be thrown out, as also must any piece that refuses to pass the " go " end.

The system is simple enough in principle, and a little thought will convince the student that if the " go " and " not go " instruction is followed rigidly, then nothing can get by that has dimensions outside the limits imposed. Every piece must undergo a test at each end of the gauge, and

so long as it does so it will be accepted or rejected; there can be no doubts whatever about its suitability for the job or otherwise. Such would not certainly be the case with the one test of the simple ring or plug gauge, that left the final decision to the judgment of the viewing workman. Some highly skilled men will scoff at this, perhaps, but we have to cater for all classes of mechanics to-day, and the limit system certainly makes things easier all round.

In the matter of the difference between the gaps or diameters of the gauges, this may be limited to the maximum or minimum specified sizes, made as exactly as possible within the scope of the tool-room equipment. As we have said just now, the " not go " sides of the gauges may be ground and finished to a size slightly in excess of the stated dimension plus or minus the limit imposed. The extent of this excess may vary according to the nature of the job, but it can be reckoned that if the imposed limit is 0.0005″, then the excess will



A plug gauge for larger cylinders.

be 0.0001″, so that the opening of the gap will be 0.0006″ above the nominal size.

There is a considerable variety of form to be found amongst gauges for testing purposes, and these we shall deal with in due course. So much difference between conditions of work has to be allowed for in the first place. The gap type of gauge is to be preferred, where it can be used, to the ring type for gauging plug sizes; it becomes, in effect, a fixed caliper that can be used to test the work in the lathe or other machine where a job is being worked by hand.

The primary object of the " go " and " not go " gauge is to make the pieces all finish out to the nominal dimension, 1″ in the case of our plug hole for instance. It has been found that the workman who can test his work as he goes along is too inclined to be satisfied with the " go " end of the gauge, and will just finish it off as soon as that end will pass on to the job. This is a principle that ought to be discouraged, simply because it means that all his work will be really oversize, not giving the clearance that is demanded.

To get over this, it is sometimes a good idea to provide a third step on the working gauge, giving the nominal dimension, and instructing the workman to work to this as far as he can. This is only useful when the process is one permitting adjustment of the cutting tool, as in turning and milling; if the cutting tool is a fixed one, such as a drill or reamer, it is out of the power of the workman to do anything about it at all.

There is another reason for using the gap type of gauge when inspecting outside measurements, and that is the risk of seizure of the ring type upon the work. Everyone who has handled a pair of reference ring and plug gauges knows the difficulty of getting them together, and, once having done so with the drop of thin oil and the quick twist, how they will almost instantly seize together. Getting them apart can be an awkward job, especially for the first time, unless you know the trick of the sharp rap on the bench and the quick twist again. Even that does not always work the first time. So if ever you put a 1″ plug gauge into a 1″ ring gauge, keep it moving, or else it will stay there till someone who understands it better than you comes along to get it out.

It is the high finish of the surfaces that makes this happen, it is thought that molecular attraction has something to do with the locking together that seems to occur. Surfaces finished ground will not often lock in this way, it is due to the high polish put on by the lapping process, and this excludes all air from between them. In the next article in this series, we shall make further reference to this subject.

The material from which gauges are made is varied enough, depending largely upon the material that has to be gauged. For gauging steel parts, the gauges will be made from tool steel, which may be either left soft or hardened. Some prefer soft gauges, because they do not respond to changes of temperature to the same degree as when hardened, thereby giving a more accurate judgment under varying workshop conditions. Cast-iron, malleable cast-iron, or drop-forged bodies can be used with adjustable steel anvils. Mild steel, with case-hardened jaws, also can be employed. There are so many factors to consider. For instance, the work to be gauged may have several degrees of finish, and the state of the finished surfaces will occasion more or less rough treatment of the gauge.

Where large sizes of gauges are concerned, the weight becomes some consideration. It may be necessary to make up a composite gauge with a body of aluminium, the actual gauging surfaces being of steel secured by screws or other methods. For internal measurement gauging, it may be necessary to do away with the plug type and substitute one with pegs such as we illustrate here. Clearly, such a gauge as this needs careful use, and must be tried in the cylinder hole in a variety of positions before a final passing. The ends of the pegs are rounded to a spherical form, though to a smaller radius than that of the hole under test. A gauge like this would be used for holes of over 6″ diameter.

(To be continued)

Roundness in Shafts

By Arthur C. Carter

IT is quite a common thing to meet capable engineers who will assert that it is possible to take pieces of ground bar which, when measured, give a constant diameter and which are not truly round, and every engineer knows of cases in which a shaft which has been measured by micrometers or verniers will prove to be stiff in a hole which has been carefully reamered to a plug gauge. This experience has been responsible for the introduction of the more frequent use of ring gauges and also for the assertion that shapes which give a constant diameter need not be round, which is, of course, a very false supposition.

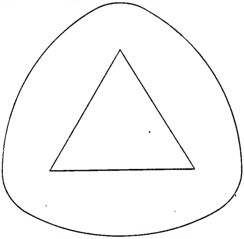


Fig. 1. A figure with a constant measurement across.

The definition in Euclid of a circle is " a plane figure contained by one line which is called the diameter, and is such that all straight lines drawn from a certain point within the figure to the circumference are equal; this point is called the centre of the circle." A diameter is " a straight line drawn through the centre and terminated both ways by the circumference." Fig. 1 is an exaggerated example of a shape which, when measured by micrometers or verniers, will give a constant reading; it is also the type of shape which sometimes results from centreless grinding. It is formed upon an isosceles triangle, and in Fig. 2 it is proved that the diameters—that is, any two lines through the centre of the figure, which is obviously the centre of the isosceles triangle—are not necessarily equal.

In Fig. 2, ABC is an isosceles triangle. O is its centre. Short arcs are subtended on A, B and C as centres with the same radius (r). With a long radius (R), these centres are joined up by arcs subtended from A, B and C. O is then the centre of the resultant figure. DOE and XOY are drawn as diameters. DA and EA are joined.

We are going to prove that these diameters, DOE and XOE, are unequal.

PROOF

XOY = XA + AY = r + R.

Now, DA = r, and AE = R.

Therefore DA + AE = r + R = XA + AY = XOY.

Now DAE is a triangle.

Therefore DA + AE is greater than DOE.

But DA + AE = XOY.

Therefore XOY is greater than DOE.

Therefore these two diameters are not equal.

Therefore the diameters of this figure are not constant.

As this certainly proves that the diameters are not equal, it will be necessary to find out why this figure gives a constant reading when measured by micrometers or vernier calipers.

Now, when we measure with micrometers or vernier calipers, the two faces with which we measure are parallel and flat. They must, then, always touch any figure tangentially. In Fig. 3, we see that any two parallel faces touching the figure subtend two normals to the centre of the arcs which they touch, and that these two normals form a straight line which is always a constant length, but which does not necessarily go through the centre of the figure and form a diameter.

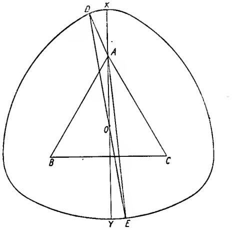


Fig. 2.

In Fig. 3, ABC is an isosceles triangle. O is the centre. LX and MY are parallel tangents at X and Y, respectively. X and Y are joined.

Now, since LX is a tangent to the arc centre A, radius r, the normal from X must go through A.

Also, since MY is a tangent to the arc centre A, radius R, the normal must go through A.

Now, since LX is parallel to MY, and LXA =

90° = MYA, XAY must be a straight line; that is, it must coincide with XY.

But XA = r, and YA = R.

Therefore XAY = XY = r + R.

Now this applies to all parallel tangents to the figure whose normals must always form a straight line = r + R.

Therefore, all measurements of the figure between parallel tangential faces must be equal to r + R and constant.

With these two differences before us it is obvious that we must be more careful in our usage of diameter as an expression meaning the measurement across a shaft; because, as we have seen, sections can be obtained which give a constant cross-reading but which have certainly not got constant diameters.

The obvious remaining course is to distrust measurements of shaft or round bar taken with micrometers or vernier calipers, because these do not give any indication of true roundness; and although the theoretical geometry just shown seems to be rather hair-splitting, its implications in practical work are enormous, and full realisation of the theoretical side is essential to clear thinking in manufacture.

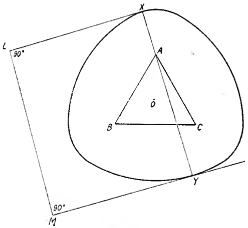


Fig. 3.

We all come across a very carefully reamered hole made to suit ground bar to the manufacturer's tolerances, and are surprised to find undue tightness. Our usual course is to measure the shaft with micrometers, and, on finding it to be correct, to assume that our hole is, perhaps, not quite right, and then we resort to emery paper or an expanding reamer to open it out. The obvious result is that in use the shaft hammers the hole a size bigger, and we have wear on our hands which is usually put down to the strains and wear and tear of the machine on the metal. The only sure course is to use a plug gauge on the hole, and, if it is correct, to scrap the bar as being not truly round. Another case which can lead to serious trouble is in the use of ground bar in valves, etc., when a bar which fits into its gland will still leak unless it is absolutely true.

There are really only two methods of testing bars for roundness without much difficulty; one is to mount it on a vee-block, as in Fig. 4, and gauge it with a comperator; the other is to measure it carefully with micrometers and then to make sure that it fits into the appropriate ring gauge—the second being the much more reliable and easiest to carry out.

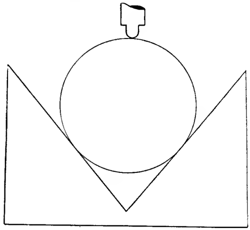


Fig. 4.

It can easily be seen how important this matter is, the rather subtle difference between constant diameter and constant measurement in round bar seems very much like one of those things with which the theoretical man alone worries himself, yet it is a thing which must be fully grasped by every practical engineer if he is to be sure that his work will be true and reliable. It is one of the points which are least understood and causes, incidentally, in big engineering works, a distrust of standards and inspection routine, encouraging a resort to expanding reamers and the consequent doubtful work.

Let us remember, then, that everything with a constant diameter is round, but that sections which have a constant measurement need not have a constant diameter and may be very far from round.

A Turned Pin Bowl or Ash Tray

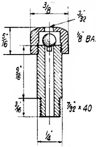
Here is a hint for Christmas. Next time you go near a timber merchant, beg some odd pieces of wood of all kinds, and as varied in colour as possible. Plane these into square or rectangular strips, or both, and glue together to form a compound piece of circular section. Clamp up hard, and forget about it. Then, on December 24th, when you suddenly remember you have forgotten all about dear Aunt Matilda's present, retire to your shop, and unearth the wood. Set it up in the lathe, and turn her a lovely pin bowl (or ash tray!). The effect is pleasing when wood of widely differing colours, such as walnut, teak, mahogany, birch, etc., are used. Sand it well while in the lathe, finishing with the finest sand-paper, then oil and finally apply some floor-polish on a piece of flannel and treadle vigorously for half-an-hour. The dear old lady will remember you for the rest of her days.—H.F.

Ten-to-Eight

By " L.B.S.C."

Snifting-Valve

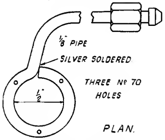
THIS useful little gadget which, for novices' information, admits air to the cylinders when coasting with the regulator shut, and thereby prevents smokebox ashes being sucked down the blastpipe, is made from a $\frac{3}{4}$" length of $\frac{1}{4}$" brass rod. Turn one end down to 7/32" diameter for 3/16" length, and screw 40 pitch. Drill right through No. 43. Reverse, and put a few threads on the other end, also cross-nick it with a saw. The cap is turned from $\frac{3}{8}$" brass rod. Face, centre, drill down about $\frac{3}{8}$" depth with No. 43 drill; then open out and bottom with a 7/32" D-bit to a full 7/32" depth, tapping $\frac{1}{4}$" by 40 for three or four threads only. Part off at 5/16" from the end; reverse, and round off as sketch. Seat a $\frac{1}{8}$" ball on the hole inside the cap, and assemble as shown, with a touch of plumbers' jointing on the threads. Insert through hole in the top of smokebox, and screw home into the tapped hole in the wet header.



Snifting valve.

Blower

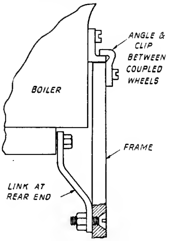
A ring blower will provide a better draught than a single jet, with less consumption of steam, in wide chimneys such as the present one. Bend one end of a piece of $\frac{1}{8}$" copper tube into a ring $\frac{1}{2}$" internal diameter, and silver-solder the joint as sketch. The other end of the pipe, which should be long enough to reach easily to the end of the hollow stay, is furnished with a union nut and nipple. Make three centre-pops in the ring, and put it in place over the blastpipe nozzle, coupling up the union nut to the screw on the end of the hollow stay. Fix a No. 70 drill in the end of a few inches of 3/16" brass rod; put it down the chimney, and twirl it between finger and thumb, with the drill in one of the centre-pops. Repeat operation on the others, and your blower will be certain to send the jets of steam up the liner. I described this method of drilling ring blowers in an early " Live Steam " note about fourteen years ago, and it has always proved very effective.



Blower ring.

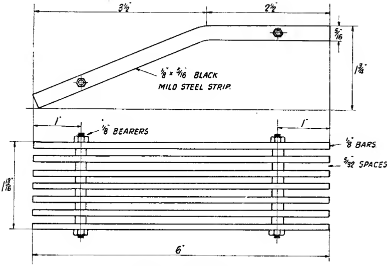
How to Mount the Boiler

The complete boiler and smokebox, with all the blobs and gadgets attached, can now be placed in position on the frames, and connected up. When the bottom edge of the smokebox wrapper is resting on the frames, and the foundation ring on the top of the trailing hornblocks, the boiler should be quite level, with the bottom line parallel to the top of frames. If it is not, your hornblock castings are not the same as those I used when setting out the job, but that does not matter a bean. All you have to do, is to set the boiler level, locating from the smokebox end, and put a bit of rod or something similar between the barrel and the top of the frames, to prevent it falling down. Two pieces of brass angle, about 1" long, and 5/16" by 3/16" by 1/16" section (5/16" by 1/16", with one side filed away a little), are then attached to the firebox wrapper by three 7 B.A. brass screws, so that the narrower side rests on the frames, see sketch. A little clip at each side, made from 1/16" sheet brass and screwed to the frame, will prevent the boiler from lifting. If the holes are carefully tapped in the firebox wrapper, using a taper tap and not entering it too far, the screws will be steam and water tight; but if there are any teardrops, the best and easiest way of drying them up permanently is to sweat completely over angle and screws, with ordinary plumbers' solder, same as the stayheads.



Alternative boiler fixings.

There is an alternative method of securing the boiler, and at the same time providing enough flexibility to allow for expansion, and I often make



Details of the grate.

week, they will part off without any burrs. The bearers are $2\frac{1}{8}''$ lengths of $\frac{1}{8}''$ rod, silver steel or mild steel, screwed at each end. The assembly is shown in the sketch. A little nick is filed in the projecting part of the firebox side sheets, to make sufficient clearance for each of the bearer nuts when the firebars are in position, level with the bottom of the firebox. As with all my engines, the grate is not fixed to the boiler in any way, but is supported by the ashpan.

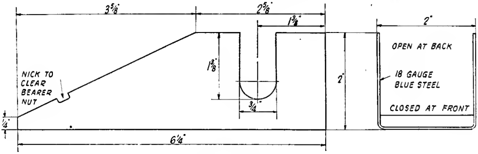
Ashpan

A piece of 18 gauge blue steel, $6\frac{1}{2}''$ by $6''$, is needed for this. The easiest way to make it, is to mark out the whole thing on the flat sheet, then cut away the surplus metal to form the sloping sides, also the gaps to clear the trailing axle. The ashpan can then be bent to shape in bench vice. I keep short lengths of black steel bar, of varying widths, for jobs like this. Do not forgot to bend up $\frac{1}{4}''$ at the front end, so as to close the opening below the throatplate, and keep the ashes and grits off the motion. Ashes, cinders and lubricating oil combine to form a grinding paste that will play Old Harry with the valve-gear and big-ends; and I find a closed-front ashpan is absolutely essential to maintain a clean set of " works."

use of it. This is to connect the projecting edge of the firebox side sheets with the frames by means of an offset copper link at each side. The sketch shows the idea, and explains itself. I usually put the links at the back corners of the firebox, so that the screw-holes are tapped through the firebox side sheets and the flanges of the door sheet. The countersunk screw in the frame is to clear the back coupled wheel.

The front end fixing was mentioned when describing the smokebox, so we do not have to cover that bit of road again.

Owing to the position of the rear coupled axle



Ashpan details.

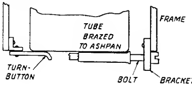
Grate

The firebars are cut from $\frac{1}{8}''$ by $5/16''$ black mild steel strip. It was originally intended to make a pattern, and get one or more of our advertisers to supply cast-iron grates complete; but owing to a certain party being rather nasty about things in general the idea did not materialise. I hope he loses his Saturday penny down a drain in the Unter den Linden, for my patience is completely exhausted. Anyway, cut seven $6\frac{1}{4}''$ lengths, bend as shown, drill No. 30 holes at $1''$ from each end in one of them, and use as a jig to drill the others. Chuck a length of $5/16''$ round steel rod in the three-jaw, centre and drill No. 30, and part $5/32''$ spacers off it until you have a dozen. Tip: if you grind the parting-tool as shown last

and the big wheels, it is not possible to use my " patent " arrangement of running a stout pin through the frames, and a tube in the ashpan, to keep the latter in place. However, there are two alternatives; take your choice. No. 1 is to rivet a small piece of angle brass to each side frame, about halfway along the ashpan, and attach a turn-button, made from 16 gauge sheet brass, to each angle, see sketch. When it is required to dump the grate and ashpan for cleaning out the residue after a run, a quarter-turn of the buttons will allow the whole issue to drop. They can be operated from outside, by poking the fire-pricker between the wheel spokes.

The other alternative is to rivet or screw a couple of triangular brackets, made from $\frac{1}{8}''$ plate,

to the frames. One has a clearing hole in it, and the other is tapped. A long bolt passes through the clearing hole, through a piece of tube brazed to the bottom of the ashpan, and enters a tapped hole in the farther side bracket. This is operated by an ordinary screwdriver through the wheel spokes.



Alternative ashpan fixtures.

Air Test

The pipes in the smokebox can now be connected up; and any interstices where they pass through should be stopped up by a little fireclay, or any of the patent fireproof cements, or else by asbestos "putty" made by kneading up a few scraps of asbestos millboard with water to a plastic mass. If the smokebox is not airtight, the boiler will not steam. Now jack up the engine so that the coupled wheels are clear of the bench, put a little air pressure in the boiler with a tyre pump, and open the regulator slightly at the same time applying a lighted taper to the open firehole. By braking the wheels with your fingers, you should obtain a series of exhaust cracks that will literally pull the flame right off the taper. Shut the regulator and open the blower. If the flame is sucked right into the firehole with only a few pounds of air in the boiler, you can pass the job O.K. in the sure knowledge that the engine is never going to be short of steam, provided that the shovel is handled with discretion.

Precision Work in a Small Shop

One afternoon, the proprietor of the outfit came in, called me into the office, and took a blueprint from his pocket. "Take a look at this," said he. "The price is umpty pounds a gross, and if we only produced three or four an hour per machine, it would be a very good line." "This" showed a rod, approximately a foot long, about $\frac{1}{4}''$ diameter, threaded for an inch or so at one end, and had an eye about an inch diameter at the other; tolerances, 0.001" plus and minus on the eye and thread, and 0.0015" ditto on the rod; material, high tensile steel. I looked at the print, and looked at him, and remarked, "I beg your pardon, Mr. Macabraham?" (That was not on his baptismal certificate, but it will do.) Something in my face must have upset him, for his fell like the mercury in a thermometer on a block of ice, and he stammered, "Well—er—why, what's the snag?" I replied, "Only your time estimate." He said, "Jhones, of the X.Y.Z., turns them out quicker than that." I answered, "Sure he does, but he has the plant, and makes them from stampings. Can you get stampings?" "No," said MacA., "but what's the matter with turning from bar?" I went to the door and called the toolmaker. "Dicky," I said, "just to settle an argument between me and Mr. Mac., how long would it take you, roughly, to turn down an inch bar of H.T., a foot long, to $\frac{1}{4}''$ with $1\frac{1}{2}$ thous. tolerance?" Dicky thought a minute and replied, "I reckon about forty minutes, chief." When he had gone, I asked the "boss" if he had definitely taken the order, and he said "Yes"; so I told him we would have to do the best we could with our limited equipment, and we would make the rods, but he must not expect to get much profit out of it; and left him looking exceedingly disgruntled.

Apart from the appalling waste of material, I did not see the fun of turning down hundreds of feet of inch bar to one-quarter its original diameter; we should have been overwhelmed with swarf, for one thing. The millwright was a pretty good hand at blacksmithing, so I got him and the toolmaker to experiment and find out the smallest diameter of H.T. that would allow the end to be knocked out large enough to form the eye. They soon found it, and the steel was ordered.

The rods, as received, were in 12' lengths, with a rough black surface. Each length was sawn into

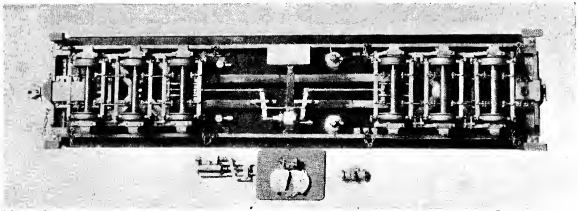


Photo by] ["*Dawson Jnr.*"

Pit view of Messrs Dawson's American tender, also steam reverser, firehole door and power grate-shaker for engine.

eleven equal parts, which just allowed for length of one rod plus a little extra for centring. The first operation was flattening one end to form the blank for the eye. The rod was then centred at both ends, placed between centres on one of the larger " not-so-accurate " lathes, and a roughing cut taken along it to remove the skin and true it up. It was then removed to an accurate lathe; and, by aid of a steady, the rod was turned to correct diameter. It was then placed in a jig on a milling machine, and the head traversed between two end-and-side cutters set on the arbor at correct distance apart. This settled the thickness of the eye. The rod was then placed in

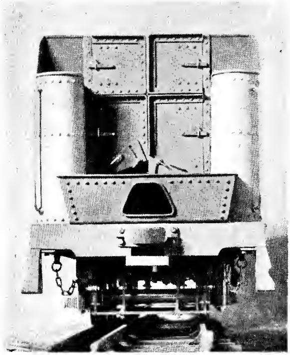


Photo by] [*"Dawson Jnr."*
Leading end of the Dawson tender.

another jig on the drilling machine, and the hole in the eye drilled a weeny bit undersize. The next item on the agenda was machining the outside of the eye, and you will now see where I got my coupling-rod-boss machining stunt from. A peg, nicely fitting the hole in the eye, was turned on the end of a piece of square steel bar, which was gripped vertically in a large machine vice and bolted to the table of a vertical milling machine. This had a long mill in the collet, something like a glorified endmill, the diameter of it being equal to the radius of the junction between the eye and the rod. The hole in the eye was slipped over the peg, and the job fed up to the cutter, the end of the rod then being swung around slowly in a horizontal half circle, so that the cutter milled away the surplus metal around the hole. Stops were arranged on the cross-slide to regulate the depth of cut, and stops bolted to the miller table (merely bits of bar, bent over at one end) governed the radial movement and prevented the operator allowing the cutter to bite too deeply into the rod at each side of the eye. The hole was then reamed to correct size.

The final operation was putting the thread on, and turning off the centre-hole. This was done in one of the small lathes, in pretty much the same way as you would do it at home. The rod was gripped in the three-jaw, after inserting through the hollow mandrel; the thread put on with a ground-out button die in a tailstock holder, and the end finished off with a combined parting and chamfering tool operated by the cross-slide. Though " Jhones of the X.Y.Z." beat us hollow on production time, with his stampings and up-to-date equipment, we beat him on one count—we had a far smaller percentage of throw-outs!

The New Soldo Drill-Saw

THE cutting of holes, of any other shape than circular, in comparatively heavy timber is always a rather awkward job, especially to the amateur with limited equipment. It is usual to carry out this work by first boring a circular hole with a brace bit, of sufficient size to admit the point of a keyhole or compass saw, and then use the latter to work outwards from the hole in the required direction. In most cases, it is found necessary to finish the hole to exact shape by means of a small file or rasp. Such operations call for a fair amount of skill and patience, and even when all care is exercised, do not always work out as neatly as one might wish.

By the use of a simple tool lately introduced by the Soldo Co., Ltd., Sicilian Avenue, London, W.C.1, the cutting of such holes is resolved into a one-tool operation, and thereby very much simplified and expedited. The tool in question embodies a combination of gimlet, twist-drill, saw and rasp, being made of square section tool steel twisted into an Archimedean spiral, and rasp-cut on the corners; the end is flattened, while still retaining its initial twist, and ground to drill cutting edges at the point. It is finely tempered so as to stand up to rough usage without fear of breakage or losing its sharpness.

In use, the tool is first employed as a gimlet to drill a circular hole in the wood, and the hole is then enlarged in any direction by using it as a saw or rasp. It cuts very rapidly and is fully under control, having much less tendency to tear out the back of the hole than a keyhole saw, and none whatever to wander or cut " on the twist " when working round a curve. Any finishing of the interior surface of the hole which may be found desirable may be carried out by means of a slip of glasspaper wrapped round the shank of the tool.

There is no question that both amateur and professional woodworkers will find this inexpensive little tool very useful. It is made in two sizes, one having a 10" blade, the other 6" long.

Loco. Coal

By Victor B. Harrison

AT the last MODEL ENGINEER Exhibition, I had a long discussion with Mr. Crebbin and Mr. Linden on the kind of coal suitable to model locomotives. It all arose from a remark about the coal that was used that day on the passenger-carrying track. One of the worst enemies of miniature coal-fired locomotives is soot, and the smaller the engine the worse it is. Therefore, good smokeless steam coal must be used in order to get the best results.

Ordinary domestic house coal is perfectly useless. Its tarry consistency makes it clog together, and also the soot formed is fatal to the small fire-tubes. It is very realistic when used, as it causes plenty of black smoke to come out of the little engine's chimney, but the tubes get sooted up in a short time, and, worse still, a hard tarry deposit forms in the interior of the little firebox. This is so hard that it has to be removed with a cold chisel or a scraper. Ordinary anthracite is too slow burning; also, there is not enough induced draught to keep the fire going sufficiently to keep steam pressure. Unless the enthusiast is in touch with someone who keeps or uses steam coal he is really up against it, especially with regard to the small sized engines.

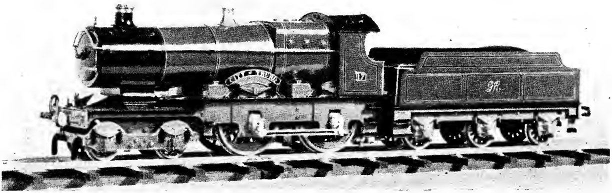
In 1916, I completed the smallest coal-fired engine built up to that time. I was not in touch with anyone who could supply me with a good steam coal, so had to content myself with charcoal. This raised the necessary steam all right to 60 lb. per sq. in., but, naturally, it did not last very long. In latter years, one of our works used a coal called "Graigola," and this proved most successful in my other engines. Unfortunately, the Chief Engineer decided to get another kind of steam coal, and once again I was at a loss to find someone from whom I could beg, borrow or steal some similar fuel. The ordinary coal merchant, when applied to for a small quantity, only shrugs his shoulders and says, Yes! he will supply, if you order five or six tons. The quantity the amateur locomotive superintendent requires is about ½ or 1 cwt., and that would last him a lifetime.

It was just about the time of the "M.E." Exhibition that I had discussed my troubles with the parent of one of my boy's school friends, who happened to be in the coal trade. When I told him of the troubles of a model engineer with regard to coal he was only too ready to help. He despatched, at once, seven different kinds of coal which he considered suitable. He, himself, came down to witness the first trials. Unfortunately, it was not a fine day and tests were interrupted by rain. Nevertheless, he saw what a big difference there was between the two kinds of coal used. The coals that he kindly supplied were the following:—

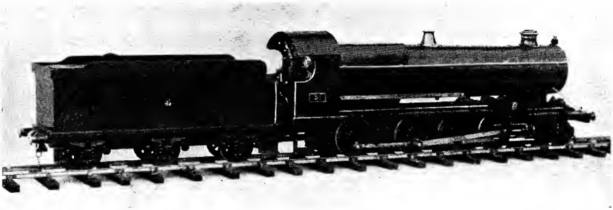
The first one was "Ocean Deep Washed Peas"—approximate volatile 14-15%. As my coal-fired locos. are gauge "1" the coal has to be screened so that the size is about the same as split peas.

For the coal test I used the "City of Truro"—grate area, 2⅞" × 15/16".

The "Ocean Deep Washed Peas" raised steam nicely and quickly, but when the engine ran with a load, pressure fell rapidly; and when the firedoor was opened the fire appeared normal, but when pricked it collapsed to the bottom of the grate, thus proving that the coal expanded during combustion. This is hopeless in such a small grate. Some "Graigola Washed Peas," which I had used previously with success, was put on the fire and my friend will bear witness that the change was most remarkable. As soon as running pressure was raised, away the engine went and



"Gauge 1" G.W.R. "City of Truro."



Gauge " 1 " G.W.R. " Consolidation Goods."

covered two laps of 400′, with the safety-valve popping from time to time. When the engine was stopped a splendid fire remained. It only required three shovels full (size of a teaspoon) and away the engine went again.

" Ocean Deep Washed Peas " were tried again, but the engine barely completed a lap, losing steam all the time, and when the firedoor was opened the fire was beyond saving.

The next fuel to be tested was " Mountain Grains," approximate volatile 10%. This is 2% less than " Graigola." " Mountain Grains " seems to be a slower burning fuel than "Graigola" but generates the same amount of heat.

The " City of Truro's " best runs with " Graigola " were three to four laps of 400′ on one firing. The fire then was low but bright. With " Mountain Grains," this engine has done four and five laps on one firing. Care has to be taken that adequate steam pressure for induced draught, by means of the steam blower, is maintained when the engine requires fresh coal. Otherwise, the fresh coal does not get properly ignited. " Mountain Grains " leaves a very clean ash and makes no clinkers at all. P.A.D.C. " Washed Peas," approximate volatile factor 11.5%, when tried was worse than the " Ocean Deep Washed Peas." It fused into a solid lump in the firebox and when the pricker was inserted it did not succeed in breaking up the lump, but just lifted it up in one piece.

" Brynteg Washed Grains," approximate volatile factor 8/9%, proved to be much too slow a burning fuel. The little locomotives cannot produce sufficient induced draught either by the blower or the exhaust. A model G.W.R. " Consolidation Goods " type of engine, to the same scale, was used to confirm the tests. Her grate area is 4″ × $\frac{3}{4}$″. With " Graigola," this engine runs one and a half laps to two laps on one firing. The reason for this is the small diameter of her driving wheels. Nearly double the amount of revolutions have to be made to cover the same distance as compared with "The City of Truro." With " Mountain Grains," the engine covered two to two and a half laps, but very great care has to be taken with this engine not to lose the fire. This engine was hopeless with the other coals.

Both Mr. Crebbin and Mr. Linden were very interested in my experiment, and offered their services to see how the two coals that I had found successful worked on their engines. I sent them each a sample. The " Mountain Grains " was about the size of a hazel nut, while the "Graigola" was about the size of a pea. On Mr. Crebbin's engine, " Mountain Grains " undoubtedly proved to be the better, while on Mr. Linden's engine he was able to obtain success with the "Graigola" by keeping a thin fire. In his opinion, if the " Graigola " had been larger it would have been more convenient, but he decided to plump for " Mountain Grains." On the larger locomotives, I am sure that " Mountain Grains " is the better fuel, as naturally their induced draught must be greater than a gauge "1 " engine. Mr. Crebbin was inclined to dispute that, as he felt sure that on his engine, especially " Old Bill," the draught might even be less.

Mr. Courtice, who has a $2\frac{1}{2}$″ engine, has tried both coals, and he feels that there is not much to choose between them. On the other hand, Wing-Comdr. Breakey, who is, like myself, a gauge "1" enthusiast, finds on test that the " Mountain Grains " lasts longer, but you have to watch your fire very carefully; while with " Graigola " things are very much simpler, and he, therefore, prefers it, although he has to fire more frequently.

Another point with these two fuels which is rather interesting is that although " Mountain Grains " is slower burning and has a lower volatile factor than " Graigola " it is inclined to smoke, but curiously enough it leaves no trace of soot at all. " Graigola," with its higher volatile factor, gives off no smoke at all, which seems to me a rather curious fact. I think it would be very interesting to hear from other enthusiasts their experiences with various coals.

Simple Photographic Enlargers

How to construct inexpensive apparatus, conforming to modern requirements, for making real pictures out of amateur snapshots

By " Kinemette "

THE advent of winter always brings with it the problem of how best to occupy one's time during the long dark evenings, and now that lighting restrictions have made the latter darker than ever, many of the diversions which might have tempted us from the domestic hearth have either departed or have lost much of their glamour, due to the difficulty of getting about after dark. Model engineers, however, should be the very last people on earth to find time hanging heavily on their hands; but apart from whether it is desirable or even possible to spend all hours of every evening in the workshop, the variety afforded by a second hobby, which offers equal scope for skill and craftsmanship, and can be carried on practically at the fireside, may be worth consideration.

A very large proportion of model engineers take some interest in photography, as may be proved by the number of cameras which are always in evidence at all outdoor (and some indoor) meetings of model engineering societies. No doubt, in many cases, the full technique of photography is shirked, and they are content to leave the processing work to the local chemist or photographic dealer; indeed, it might well be contended that the serious study of photography would demand practically all one's leisure time, to the exclusion of all other hobbies.

It is quite unnecessary to deal at any length with the attractions offered by the possibility of being able to reproduce, in any reasonable size, the small photographs taken by one's own camera; this is a subject which has been ably exploited by every photographic journal and handbook. Every amateur photographer who has attained even moderate success must have accumulated scores of negatives which are simply crying out to be enlarged; and all that is aimed at in this treatment of the subject is to show readers how to find the ways and means to do so, without the need to purchase costly and elaborate apparatus.

Makeshifts not Recommended!

Everyone will realise that the joy of achievement, which follows the accomplishment of every skilled task, is enhanced tenfold if one has done it with the aid of an implement of one's own contriving, and this fact should be sufficient excuse, if indeed such is necessary, for the attempt to construct photographic apparatus. But, perhaps, it is advisable to introduce the subject with a note of caution, if only to anticipate the cynical remarks of those who have seen, and, perhaps, tried to use, home-made enlargers—of sorts—and are by no means favourably impressed.

Many of us are undoubtedly familiar with the type of " apparatus " such critics have in mind—

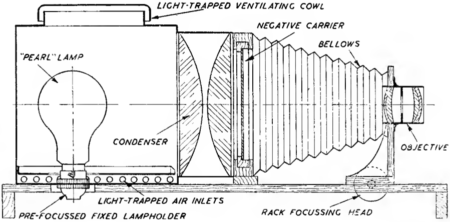


Fig. 1. A typical artificial light enlarger of the horizontal type, incorporating bellows extension with rack focussing, and a condenser illuminating system with pre-focussed lamp.

a " Heath Robinson " conglomeration which usually incorporates an ancient camera and a biscuit tin, lashed together with string, and the futility of attempts to black-out light leakage by yards of adhesive tape admitted by the desperate expedient of enveloping the whole in a focussing cloth! It must be admitted that such a contraption can, by dint of perseverance, be made to

But, even while one may agree with this contention, and also recognising the futility of " dabbling " in two or three hobbies and mastering none, it is still possible to develop a more practical interest in photography without neglecting model engineering—especially when the necessary apparatus for doing so forms quite an interesting subject for the model workshop.

yield results of the highest photographic quality, and many of us, including the writer, will confess to having used something like it in circumstances of dire necessity. But its limitations and faults are so glaring that occasional successes cannot possibly wipe them out; how many exposures have been ruined by someone walking across the next room, and causing the entire hook-up to quiver like a jelly; or by faults in the extemporised black-out arrangements, uneven illumination, and so on; while the proceedings are sometimes enlivened by the lamp-house getting almost red-hot, and the operator being nearly suffocated by the fumes of scorching paper and fabric. One adventure is recalled in which the entire outfit caught alight, and though little damage was done by the fire, the mess caused in its extinguishment, and the flutter in the domestic hen-roost, are painful memories.

If one essays to build an enlarger, therefore, it very definitely pays to do the job properly, from the point of view of both design and construction, as a properly-made device will always be reliable and ready for use, quick and convenient in operation, and, in short, a pleasure to work with. The object of these notes is to enable the essential principles and methods of construction to be fully grasped, so that practically any type of enlarger may be successfully constructed.

Working Principles of Enlargers

As most readers are aware, a photographic enlarger is nothing more or less than an optical projector, generally (but not exclusively) of the "diascopic" type (that is, having the source of light *behind* the subject to be projected, and the latter being partially transparent, so that the light is transmitted through it), and having certain specialised features of design to improve its utility, convenience and efficiency for its particular duty.

Light Trapping

An obvious requirement of any photographic enlarger is that leakage of light must be strictly eliminated. In the case of an ordinary optical projector, a certain amount of light leakage is tolerated, though it may be inconvenient, or even fatal to good projection, if carried to extremes. But in a photographic enlarger, any white light which emerges anywhere except by its designed path through the optical system, may, either directly or indirectly, reach the surface of the sensitive material, either on the enlarging easel or elsewhere in the room, and thus cause fogging. Efficient light-trapping is, therefore, absolutely essential, and one of the problems in enlarger design is, therefore, how to keep the lamp-house efficiently ventilated while preventing the escape of light.

To some extent, this problem is associated with that of conducting away heat and keeping the lamp-house reasonably cool, but in this respect the difficulty is usually less acute than in optical lanterns of substantial power, as it is not absolutely necessary to use very powerful illuminants. It is thus possible to make the lamp-house smaller, and also to decrease the size of ventilating apertures, but in devising screening to prevent direct light emerging from the latter, the need for a free flow of air by convection should not be neglected.

Illumination

Nearly all enlargers nowadays are designed to employ electric filament lamps, and in present circumstances it is very doubtful whether any other form of illuminant is worth while considering, as there is nothing to compare with electricity for efficiency, convenience, cleanliness and constancy of illumination. Even in cases

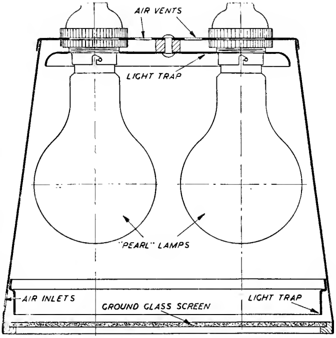


Fig. 2. A simple form of diffused-light illuminator, arranged for use with a vertical enlarger.

where mains supply is not available, it is quite practicable to use low-voltage lamps run from battery supply.

The strength of illumination required for enlarging will depend upon circumstances, such as the density of the negative to be dealt with, the extent of the magnification, the aperture of the objective lens, and the system of illumination adopted. Generally speaking, the power is extremely low as compared with that required by optical lanterns, which have to project a very highly magnified picture to a high standard of brilliance. It is true that many enlargers have been made to take arc lamps, or cluster filament projection lamps up to 500 watts, but for most purposes very much lower-powered lamps are quite adequate. The evenness of illumination is most important, and imperfections in this respect which are hardly noticeable in ordinary projection, may be absolutely fatal in photography. Generally, it

is desirable to soften the lighting somewhat, and this is quite easily accomplished by using domestic lamps of the "pearl" type, although on purely optical grounds, these are all wrong, and in spite of the diffusion produced by the obscured glass bulbs, the distribution of the filaments may prevent ideal evenness of illumination being attained. Photographers are still waiting for a perfect enlarging lamp to be introduced, but if, when it does arrive, it costs a good deal more than ordinary lamps, they will probably continue to use 6d. "pearl" lamps from Woolworth's!

Low-voltage lamps are, in this respect, much to be recommended, as the compactness of the filament facilitates even illumination, and even when it is desirable to introduce a diffusing screen, the efficiency is still much better for a given voltage than that of high-voltage lamps; another important point is that, as the filament is run at a higher temperature, the light produced has a higher actinic value. It is also much easier to regulate the supply voltage to such lamps by means of a rheostat or stepped transformer, to accommodate the requirements of negatives differing widely in density.

The majority of enlargers employ an illuminating and optical system identical with that of the ordinary diascopic lantern; that is to say, incorporating a condenser of suitable diameter to cover the subject to be projected (i.e., the negative) and suitable focal length to focus the rays of the lamp through the front lens or objective. This system, shown in Fig. 1, leaves little to be desired, from any point of view, but several variations have been introduced with the object of either simplifying and cheapening the construction of the enlarger by eliminating the condenser, or of improving the diffusion and evenness of illumination. The actual efficiency of the illuminant with such systems, however, is generally very much lower than when a condenser is employed, though in some modern enlargers, the use of parabolic reflectors, often in conjunction with specially local-obscured lamp bulbs and graduated diffusion screens, this disadvantage is very much reduced. In the absence of these provisions, however, diffused light enlargers generally require from four to five times the candle-power, as compared with condenser enlargers, to produce equivalent screen illumination. A further disadvantage, in systems where no attempt is made to concentrate the light optically through the objective, is that the indiscriminate scattering of the diffused rays may interfere with the projected rays and so cause partial fogging. It is, in fact, alleged by some authorities that the increased "softness" of the results obtained by such enlargers is little more than the effect of this dispersion; but others claim that diffused light minimises the obtrusiveness of scratches or other surface blemishes on the negative.

(To be continued)

For the Bookshelf

Newnes' Complete Engineer. (London: Newnes & Pearson, Ltd.) In about 40 Weekly Parts, price 1s. per part.

This publication makes its appearance at an opportune time, in view of the importance of engineering in all departments of national service, and the urgent need for trained engineers to carry on vital industries. It constitutes a complete encyclopaedia of modern engineering practice, including workshop processes and methods, machine tools and production, erection and installation, operation and maintenance of engines and machinery. Articles under each of these headings, written by recognised authorities on the respective subjects, appear in each part, and the entire work is edited by Lt.-Col. D. J. Smith, O.B.E., M.I.A.E.

Part 1, which has been submitted to us for review, contains the following articles: "How to Read a Blueprint," "Engineering Production, from Design to Despatch," "Practical Notes on Ball Bearings," and "The Modern Cold-Start Oil Engine," together with a "Data Sheet on Transmission Shafting." The treatment of the subjects is practical rather than theoretical, and all articles are well illustrated with drawings and photographs.

The complete work has been planned so that it can eventually be bound into four volumes, and in this form it will undoubtedly constitute a valuable and comprehensive work of reference.

Young Chemists and Great Discoveries. By James Kendall, M.A., D.Sc., F.R.S. (London: G. Bell & Sons Ltd.) Price 7s. 6d. net.

This book consists of a collection of lectures that have been delivered at the Royal Institution to juvenile audiences. The lectures deal with the work of the world's great chemists, and include certain personal anecdotes as a measure of light relief from the essentially scientific matter. Without exception, these lectures are highly entertaining, instructive, and often amusing; yet their scientific and educational value is not in the least impaired. We confidently recommend this book to children, their parents, and all who have ever enjoyed a series of delightful scientific lectures.

Methods of Metal Aircraft Construction

By "Ned"

SEVERAL methods have been employed or proposed for the fabrication of metal aircraft, the most successful being by welding and riveting. The former method was, up to a few years ago, particularly favoured by Continental manufacturers, and quite successfully used in the construction of several types of air-frames, but although superficial consideration of this method might indicate that it is unsurpassable for strength, there appear to be certain inherent limitations and disadvantages in its use, which restrict it mainly to low or medium stressed constructions.

In the first place, welding is only applicable to a comparatively narrow range of materials, mostly those of only moderate tensile strength, as aircraft materials go nowadays. Many high-tensile alloys which are most desirable for constructional purposes have very difficult welding properties, and are liable to be so altered locally by heating as to lose their special properties, or even to be dangerously weakened, unless the entire component, after fabrication, can be carefully heat-treated as a whole, which is not usually practicable owing to its bulk. Also, it is practically impossible to estimate the strength of a welded joint, except by the destruction test of an individual piece (which may or may not be typical of the rest of the batch from which it is selected) or by minute inspection by X-rays of the entire length of the joint. Welds which appear to be perfectly sound may have small inclusions of slag or oxide which, while not seriously affecting strength, may form the foci of subsequent trouble after the structure has been subjected to vibration and fatigue.

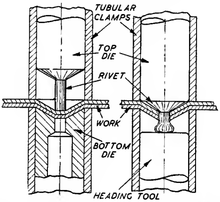


Fig. 1. Two stages in the punch-riveting process, showing (on left) the rivet, having depressed the sheets into the bottom die, and about to pierce the hole, and (on right) rivet held in place by top die for the heading operation.

These remarks apply with greater or less force to practically all methods of welding, including seam, spot and fusion methods, and the problems are generally more acute with aluminium alloys than with steel. Most of the successful welded aircraft components or complete airframes have been in low-tensile (of the order of "mild" or Bessemer) steel, generally in the form of tubes, and within certain defined limits of performance; these have been quite satisfactory, though their record is somewhat marred by occasional unexplained mishaps which, in the absence of definite evidence, can only be presumed to have been caused by the failure of some important load-bearing or control structure.

High-performance aircraft of recent years have generally been of riveted structure, and in this respect it may be noted that British aircraft factories, so far from conforming to the accredited national trait of being backward with every new process or development, may be considered true pioneers, and quite early in the history of metal aircraft had developed highly scientific and reliable methods of fabricating light high-duty metal structures. In nearly all cases, the material which has been and is employed is high-tensile steel, in thin strip, sheet or tube, usually stiffened by corrugating or flanging, and joined by solid or (more commonly) tubular rivets of alloy steel, of a strength proportionate to that of the rest of the structure, but sufficiently ductile to stand the closing operation without risk of work-hardening or fracture. The method of closing is in most cases by pressure, which ensures a perfectly constant stressing of the rivet, and enables the strength of the finished structure to be estimated within fairly narrow limits.

Such structures are, for a given strength, comparable in lightness to light alloy structures produced by any method of fabrication, and much lighter than any form of welded steel structure; in addition to which, their reliability under long and arduous conditions of service can be guaranteed. There are, however, certain inherent problems in the riveting of thin sheets and other light sections, not the least of which is that the fragile material is very liable to stretch and buckle, especially if expansion of the rivet, in the direction of its diameter, occurs during the heading process. It is, therefore, necessary to ensure that the upsetting of the rivet is carried out in such a way that this fault does not arise, whether hand or machine methods of riveting are employed; the rivet must hold by friction against the flat surfaces of the plates, rather than by shearing stress.

In order to increase the grip of rivets in very thin sheets, it is common to deliberately deform the latter around or in the vicinity of the rivets holes, in such a way that apart from stiffening the sheets, the area of gripping surface is increased, and the sheets are interlocked against motion tending to shear the rivet. A very successful method in flush riveting, where flatness of surface must be

maintained, is to use a rivet with a countersunk head, larger and shallower than usual; but the recess in the sheets to accommodate it, instead of being produced by a cutting tool, is indented in both sheets by a drawing operation performed by top and bottom dies, either subsequent to or simultaneously with the punching of the holes.

In the construction of German military aircraft, the use of welding methods has declined very considerably, and riveting has correspondingly increased, in recent years. The use of aluminium and magnesium alloys, which have always been favoured in Germany, is still predominant—probably the scarcity of high-tensile steel has some bearing on the choice of material—and in the fabrication of the airframes some interesting methods of riveting have been developed. In most of these, it would appear that the most important factor considered has been speed, but whether this desirable requirement has been obtained without affecting the quality or reliability of the work is in some cases open to dispute.

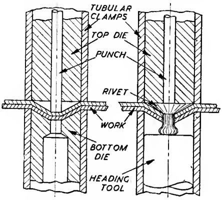


Fig. 2. A similar riveting process in which the drawing and piercing of the sheets is performed by a separate punch.

In the Heinkel aircraft works, machines are employed which combine the operations of form pressing, hole punching, inserting the rivet, and heading it. The complete riveting process is varied slightly to suit the particular class of work in hand, but in all cases the operation is performed by a sequence of motions of top and bottom dies, enclosed inside tubular clamping heads which hold the work in position while it is being operated on. In what is known as pin-riveting, applicable to aluminium alloy sheets up to 2 mm. total thickness, or Elektron up to 4 mm., the rivet, which is made of a somewhat harder alloy than the sheets, is utilised as the piercing punch and also the drawing die to form the countersunk recess to accommodate its own head (Fig. 1). This motion is performed by the top die, having a plain flat head which simply pushes the rivet downwards until it is right home in the sheets, the underside of the latter being supported by a bottom die, pierced to clear the rivet, and countersunk to take the depression in the sheets. When this motion is completed, the bottom die is replaced by a flat or formed heading die, which travels upwards and heads the rivet, either by a single blow or steady pressure, or by repeated percussion produced by pneumatic mechanism. During this operation, the top die is held at the bottom of its stroke to hold the rivet in position; after which it is retracted, the tubular clamps released, the sheets are fed forward to the next position and reclamped, and another rivet is fed under the top die.

The machine which performs these operations automatically is pedal-controlled, and has a speed of operation up to 1,800 rivets per hour on straight line riveting.

A somewhat similar method, suitable for aluminium sheets up to a total thickness of 3.5 mm., or Elektron up to 6 mm., and for rivets up to 4 mm. dia., employs a separate punch which draws and pierces the sheet prior to the insertion of the rivet (Fig. 2). This punch passes through a centre hole in the top die, which forms a guide for it during these operations; both the punch and the die are then retracted, the rivet fed in, and they then travel down together, and are held flush during the heading operation.

The same aircraft works also employs extensively a method of riveting which is capable of operation entirely from one side of the work, and is thus applicable to the fabrication of enclosed components, to which access to the inside, for the purpose of holding up, is impossible. This is accomplished by means of a special rivet, which is bored or billet-pierced axially, and loaded with an explosive charge (Fig. 3). The rivets are inserted in holes previously drilled or punched in the sheets, and the charges exploded by heating the heads, for which purpose an electric resistance heater is usually employed, but in emergency, an ordinary soldering iron or similarly heated metal bolt will produce the required effect.

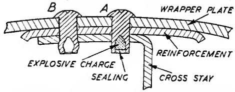


Fig. 3. Section of a portion of a fabricated streamline strut, to show the application of explosive rivets. The rivet A is shown inserted ready for ignition, and that at B, after expansion.

The explosion expands the point of the rivet, and provided that the length of the latter and the location of the charge is correct for the thickness of the sheets being joined, will tighten the joints in the same way as a normally headed rivet. It is stated that the bulging effect is very uniform, but great care is necessary to ensure accurate concentricity of the bore, as error in this respect would involve a risk of the rivet bursting, or expanding unsymmetrically, an eventuality that seems more than likely to occur.

How Electricity is Measured

(3) The Volt and the Ohm

By H. Chapman Pincher, B.Sc.

AN electric current is simply the flow of tiny particles called electrons, and the passage of electrons along a wire is very similar to the flow of water along a pipe. Water will flow only when there is a difference of level between the two ends of the pipe. Electricity will flow only when there is a difference of "level" between the two ends of the wire, but this difference is not a difference in height as in the case of the water pipe. It is really a difference in the number of electrons at the two ends of the wire. If at one end there are fifty electrons and at the other only ten, then electrons will flow along the wire from the end where there are many to the end where there are few. This difference in number is spoken of as a difference of *potential*. A region rich in electrons is said to be at *high potential*, whereas a region poor in electrons is said to be at *low potential*. Only when there is a difference of potential will a current flow and an electric battery or accumulator is simply a contrivance which by chemical means maintains a difference of potential. The electrons flow from the region of high to the region of low potential.

In the case of a pipe containing water, the greater the difference in level between the two ends the greater will be the rate at which the gallons of water flow down the pipe. In order to flow, the gallons need energy. Unless there is a slope, the gallons of water cannot flow. Therefore, it is the slope which gives the energy to the water, and the greater the slope, the greater the amount of energy given to each gallon. In the case of an electric current running along a wire, the coulombs of electricity need energy to run along the wire. They cannot flow without a difference of potential. Therefore, it is the difference of potential which provides the energy, and the greater the difference of potential, i.e., the greater the difference in the numbers of electrons at the two ends of the wire, the greater will be the amount of energy given to each coulomb. (One coulomb is that amount of electricity needed to deposit 0.000329 grams of copper on a copper plate immersed in a solution of copper sulphate.) From this reasoning, it is possible to measure difference of potential. It is impossible to count the electrons at the two ends of the circuit and subtract, but we can find how much energy is given to each coulomb, and the greater the amount of energy we find each coulomb possesses, the greater must be the difference of potential which supplies that energy. The energy is measured in joules, and the total number of joules divided by the total number of coulombs gives the number of joules each coulomb has. (One joule is approximately the amount of heat needed to raise the temperature of $\frac{1}{4}$ gram of water 1°C.) The answer will be in joules per second. This could be abbreviated to j.p.s., but instead the word *volt* is used, the unit being named after the scientist, Allesandro Volta. One volt is that difference of potential which gives one joule of energy to every coulomb. A 20 volt electric train can be run from an accumulator which gives 20 joules to every coulomb it produces. More conveniently, a transformer can be used. This is simply a convenience whereby the voltage of the mains is reduced to the required figure.

Of the substances which conduct electricity, some conduct it very readily and others not so well. Nearly all substances offer appreciable resistance to the flow of electrons through them, and in the same substance, e.g., copper, the resistance differs with differing length and thickness. Just as a narrow pipe offers more resistance to the flow of water than a wide one, so a thin wire offers more resistance to the passage of a current than a thick one. Resistance is very similar to friction, and in each case heat is produced. In the case of a moving object, such as a motor-car, some of the mechanical energy is wasted in overcoming friction. This energy appears as heat. In the case of a resistant wire, some of the current is wasted in overcoming the resistance and appears as heat. The electric fire and the electric iron depend upon this fact, and contain a specially resistant series of wires. So great is the resistance afforded by an electric light bulb, that the filament becomes white hot and produces light as well as heat. In ordinary house-lighting flex, the numerous thin wires act like a single wire, so that resistance is small and the wire does not get hot.

We have seen that it is the difference of potential which gives energy to the coulombs of electricity so that the electrons can travel along a wire. The greater the resistance offered by the wire, the greater the amount of energy needed by each coulomb. The resistance of the wire may be so great that a potential difference of one volt is insufficient to make a current pass through it. The potential difference, i.e., the voltage, must, therefore, be increased. In a house-lighting system, the resistance of the whole circuit is so great that over 200 joules of energy must be given to each coulomb in order that it shall be able to pass along the wires. We can compare voltage with pressure and imagine that the greater the voltage, the greater the pressure with which each coulomb is forced along the wire.

Since many electrical appliances depend upon

this property of resistance, industrialists require some method of measuring the resistance of the materials used in their manufacture. Resistance is quite simply measured. In the wire they are testing, the electricians find how many volts are needed to pass one ampère through it. The result is the resistance expressed in volts per amp. Once again a single word is chosen instead of the abbreviation v.p.a. The word chosen is *ohm*, after the German scientist, Georg Simon Ohm. A wire is said to have a resistance of one ohm when a potential difference of one volt is needed to send a current of one amp. through it.

The main units used in electricity may be summarised as follows:—

Coulomb. One coulomb is that amount of electricity needed to deposit 0.000329 grams of copper on a copper plate immersed in a solution of copper sulphate.

Ampère. One ampère is a rate of flow of one coulomb per second.

Calorie. One calorie is the amount of heat required to raise the temperature of one gram of water 1°C.

Joule. One joule is 0.24 of a calorie.

Watt. One watt is the rate of flow of one joule per second.

Volt. One volt is that potential difference which gives one joule of energy to every coulomb.

Ohm. One ohm is that resistance which needs a potential difference of one volt to send a current of one amp. through it.

Accumulators—Their Selection and Use

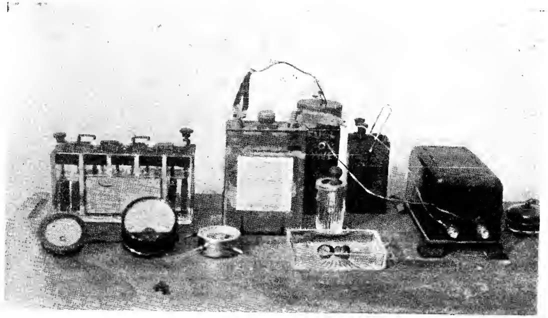
By Waring S. Sholl, A.M.I.E.E.

THERE can be no doubt that where a supply of current, for testing or supplying small motors or lamps is required, the accumulator, or secondary battery, has it every time.

Batteries coming within the scope of this article include capacities. up to 50 ampere hours and cover three broad types, viz., high discharge, normal discharge, and slow discharge. The general type technically speaking, dealt with in the present article is of the " lead-acid " order as distinct from the nickel-iron alkaline type.

The rate of discharge is highly important as indicating the output performance of the battery, as the capacity is based upon a definite rate of discharge. If this is increased unduly not only will the cell be run down more quickly, but the capacity will be reduced in actual terms of useful output. From this it will be gathered that it is essential to adhere strictly to the declared rating if the battery is to yield its required output and to have a long and useful life.

All batteries are rated in terms of ampere hours, that is, a ten ampere hour cell would yield one ampere for ten hours, but not ten amperes for one hour. This " ten hour rate " is the one adopted by general agreement for batteries of the normal discharge type as used in lighting installations. In cases where a discharge of ten amperes is required the cells, at the ten hour rate would obviously have to be of one hundred ampere



The author's charging bench. On right, metal rectifier for charging ; left, voltmeter, also ammeters for testing.

hours capacity, i.e., 10 × 10. Batteries of the multi plate type, as used for wireless and other portable purposes, are declared at the 20 hour rate and will, therefore, yield rather less output than the ten hour rating unless the discharge is limited to the *actual* capacity. Thus a cell declared at 20 ampere hours at the 20 hour rating should not be discharged at more than one ampere if the full capacity is to be expected. Cells of this type always have an odd number of plates; the negatives exceeding the positives by one. Thus they include three, five, seven or more plates according to capacity. High discharge batteries, of the car starter type, have a larger number of thinner plates to afford a greater surface of active material.

On the other hand "slow" discharge cells often have two thick plates per unit cell, one positive and one negative. These plates are designed for a very low rate of charge and discharge, and do best on testing and such work as requires a fractional ampere discharge. These cells have a compensating feature in holding their charge for long periods, and in standing idle without undue risk of sulphation.

The essential parts of an accumulator include the container, of glass, celluloid or plastic moulding, the positive and negative plates and the electrolyte. The plates consist of lead "grids" pasted with lead oxides; the electrolyte, which covers the plates, is dilute sulphuric acid. When such a combination is subjected to the action of an electric current electrolysis takes place which converts the lead oxide at the positive pole into lead peroxide, PbO_2, and at the same time reducing the oxide at the negative pole to spongy metallic lead Pb. The electrolyte, H_2SO_4 + water, H_2O, about three parts of water to one of sulphuric acid, has a specific gravity, i.e., its weight or density as compared with water, of 1.200. The gravity, which should be checked against the maker's label, and has a highly important bearing on the action of the cell, is read by means of an hydrometer which floats a graduated scale, or a set of proportionately weighted beads, according to the density of the electrolyte.

And now for some practical work in putting the new battery into commission. In the case of a five plate cell this will probably be rated at 20 amp. hrs. at the 20 hr. rate. The charging current will be 2 amps., and will continue for 10 hours, when the battery has been "broken in" to its job. The first charge will exceed this time as not all plates are fully "formed" when made up into batteries. In any case it is well to err on the safe side as the useful life and the efficiency of the cell will largely depend upon the initial care meted out to the plates, and the electrolyte.

In mixing the acid pure, or distilled, water is placed in a glass or other acid proof non-metallic vessel and pure brimstone sulphuric acid, three of water to one of acid, poured into the water—and NOT *vice versa*—in a fine stream keeping the mixture well stirred with a glass rod. Considerable heat will be evolved in the process, and the acid must be allowed to cool to normal temperature, and the gravity checked before it is placed in the cells. The battery is filled preferably by a rubber ball syringe and the acid must be allowed to settle and filled again until the air is expelled and the proper quota of acid is admitted, i.e., just over the tops of the plates. The normal voltage on open circuit is just over 2 volts which rises appreciably as charging proceeds, as also does the specific gravity of the electrolyte.

The "charger" will, in the majority of cases, consist of a metal or valve rectifier of the commercial type having an output of one to two amperes. This must be connected up positive—red—terminal to positive battery terminal and, of course, negative to negative, and the circuit closed. The battery *may* be charged shortly after filling with acid, but it is better to allow it to stand for a few hours in order to let the electrolyte percolate well into the plates. Once on charge it is advisable for the process to continue until the cell is fully charged. This is indicated by the rise in gravity of the acid which will be about 1,300, or as indicated on the battery label. A further indication is the "milking" or "boiling" of the acid due to large masses of bubbles of a mixture of oxygen and hydrogen gases. When the gravity ceases to rise further and the electrolyte "boils" freely, after 15 to 20 hours according to state of the "raw" plates, the battery is charged and should be disconnected. Any acid spray should now be wiped away and the vents, screwed back into place. The terminals should be kept very dry and clean and smeared with vaseline.

A type, used to a considerable extent in portable wireless sets, uses a "jelly" acid as a precaution against spilling. This type of electrolyte is only to be recommended where no chances can be taken with "free" or liquid electrolyte. There is no essential virtue in this preparation, and in no case should it be put into batteries designed for "free," acid electrolyte. Obviously the gravity of a semi-solid electrolyte cannot be taken by an hydrometer, and therefore an important check on the health and performance of the battery is rendered inoperative.

In the same way glass is preferable to celluloid for containers as being absolutely acid-resisting and neutral. In the case of celluloid batteries it is advisable to empty out the acid after the first charge and refill with fresh acid of a like gravity. Cells in charged condition should never be left empty for any appreciable time, as this causes heating of the negative plates which is highly undesirable.

Batteries should never be left in an uncharged state for long, as this causes sulphation and the eventual ruin of the plates. Accumulators are subject to no "inherent vices," and will give excellent service in return for proper care and attention. Use nothing but pure acid and water for the electrolyte. Avoid "dopes" like the plague.

Queries and Replies

Enquiries from readers, either on technical matters directly connected with model engineering, or referring to supplies or trade services, are dealt with in this department. Each letter must be accompanied by a coupon from the current issue, with a stamped addressed envelope, and addressed: "Queries and Service," THE MODEL ENGINEER, 60, Kingsway, London, W.C.2.

Queries of a practical character, within the scope of this journal, and capable of being dealt with in a brief reply, will be answered free of charge. More involved technical queries, requiring special investigation or research, will be dealt with according to their merits, in respect of their general interest to readers, such as by a short explanatory article in an early issue. In some cases, the letters may be published, inviting the assistance of other readers.

In cases where the technical information required involves the services of a specialist, or outside consultant, a fee will be charged depending upon the time and trouble involved. The amount estimated will be quoted before dealing with the query.

Only one general subject can be dealt with in a single query: but subdivision of its details into not more than five separate questions is permissible. In no case can purely hypothetical queries, such as examination questions, be considered as within the scope of this service.

7,724.—Trembler Coils—F.B. (Box 34, Essex, Ont., Canada)

Q.—There are trembler coils and non-trembler coils, can you describe the difference; also, which is best for high-speed gasoline engines (petrol) for racing boats?

A.—The essential difference between a trembler coil and a non-trembler coil is that in the former, the abrupt breaking of the primary circuit, necessary for the production of the secondary voltage, is effected by means of a magnetic device operated by the coil itself, in the same manner as the vibrator of an electric bell or buzzer. In the latter type of coil, however, a mechanically-operated contact-breaker is employed, and this method is considerably more efficient for high speed, as the magnetically-operated breaker has a natural frequency which may be out of phase with the cycles of the engine, and in any case introduces an element of time lag, though it is possible to counteract this to some extent by advancing the ignition more than is normally required. Trembler coils are practically obsolete on modern high-speed engines.

7,727.—Synchronous Motor for Clock—G.H. (Gloucs.)

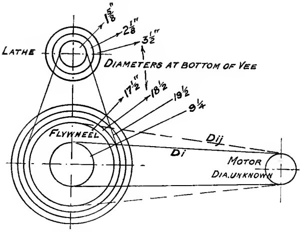
Q.—Would you please give me some particulars of a small synchronous motor (electric) suitable for an electric clock, consuming approximately (a) 1 watt, (b) 10 watts, 230 volts, 50 cycles. Particulars I should like are:—

(1) Gauge and number of turns of enamelled wire.
(2) Size of magnetic field core.
(3) If number of pole pieces on armature affects field winding.
(4) Effect of small and large diameter of armature.

A.—The sketch you submit showing an armature $2\frac{1}{4}''$ diameter by $\frac{5}{8}''$ core length is unusually large for the average clock movement, and it is suggested that ycu reduce this to about 1″ in diameter and $\frac{1}{4}''$ length of core, this providing sufficient torque for any clock with balanced hands for not more than 12″ diameter of dial. The number of slots in the rotor should correspond in pitch and shape with those formed in the pole faces of the laminated magnet, the speed being determined by the number of rotor slots and the frequency of the supply current. The standard frequency of supply being 50 cycles per second, the rotor will move forward one tooth for every alternation of current, so that if provided with 50 slots the rotor would make one revolution in one second on a circuit of 50 cycles frequency. From this as a starting point, the gear train can be worked out, or the number of rotor slots modified to suit some existing train. The winding of the exciting coil is a difficult job owing to the extremely fine wire. For a consumption of 1 watt on a 230 volt circuit, assuming inductance and resistance to be approximately a four-to-one ratio, about 1,200 turns would be needed in the coil, or say 0.17 oz. of No. 44 s.w.g. enamel covered copper.

7,734.—Drive for 3 in. Britannia Lathe.—E.B.M.A. (Porthcawl)

Q.—Can you give me some information on the following question? I wish to drive my lathe, a 3″ S.C. Britannia, by electric motor. I am having a $\frac{1}{4}$-h.p. BTH for the purpose, and a rough sketch of the drive I would prefer if feasible. I do not want overhead if it is possible to do without it, but if it is necessary I must adopt it. I give a rough sketch, not to scale, of my idea. The lathe is an old one, but in perfect order, as it has been taken great care



of and has not done a great deal of work. The small wheel on the lathe is cast integral with lathe flywheel for overhead, but I do not use this. I would like to know diameter of motor driving wheel, and which of the drives would be suitable, D.i or D.ij.

A.—Your arrangement does not work out very satisfactorily.

As a matter of fact, this is based on an assumption of the motor speed, which is not given. The assumption is that it runs at 1,450 r.p.m. Then a $1\frac{1}{2}''$ pulley on motor driving the largest wheel, $19\frac{1}{2}''$ diameter, gives a wheel speed of 112. Then, if you use the $9\frac{1}{4}''$ wheel to drive the $3\frac{1}{2}''$, or largest on the cone of lathe, the speed will be about 315, which is somewhere about the mean single speed of the lathe, and, incidentally, the slowest single speed that you can get. In this case, the highest single speed will be roughly 1,300 by gearing the $18\frac{1}{2}''$ to the $1\frac{5}{8}''$. This is abcut the fastest this lathe should go, and is a general suggestion for the best method of belt gearing as you have it.

Readers' Opinions

The Private Workshop

DEAR SIR,—I am glad I purchased your paper, dated October 5th, this morning.

I happen to be the electrical engineer of an important iron and steel consulting business, but I have always held that private workshop practice, whether for domestic use or model making, is a necessary part of a balanced man's life.

The strange thing, however, is that some of the best engineers have no manual ability whatever, and, conversely, many men in whole-time clerical or business occupations produce quite remarkable model engineering works.

These exceptions, however, do not weaken my conviction that some manual recreation is necessary in the daily work of those who choose administration or planning.

The Struggler

From this you will assume that I am a keen model maker, possibly also with a well-equipped workshop, but working as a " lone hand." Nevertheless, you are wrong, because I have been struggling in a desultory way for years to construct a quite impossible little locomotive, in a cramped shed which is hardly tenable in the winter months, and my activities are known to the local model engineering society who still ask me in a kindly way " how am I getting on?" The ashamed or guilty answer is always the same, that I am too busy with steelworks or A.R.P..

To a great extent that is true, and the reason I do not attend their meetings so often is partly that my family have some claim on my spare time; and also that I have a secret ambition to lie doggo until I can show them something again that is not so stale as the half-finished locomotive.

Now why do I bother you with this dismal personal story? Because, after all, we always return to the cramped shed again to release our minds from the day's work. Does it matter really what we make? It would be easy to say " No," but better to resolve again to finish something, whether good or bad, for therein lies determination not to be beaten.

Carry On

With these thoughts in mind, the tools out and planning again, what does a war matter? With the mind rested and interested we can tackle full-size work with renewed vigour, as well as carry out our war duties calmly and efficiently.

I think the mistake that some model engineers make is that they devote too much time to their hobby. Certainly they do produce something worth seeing, but this must not interfere with their real job in life.

It is poor consolation to be a giant in the local society and a mediocre workman during the day. This remark is not aimed at any of the members of my local society, because there are giants there who are first-class at their daily work also. It is merely a warning to those younger people who have yet to make their way, but who have sensed, fortunately, the value of craft to their powers of reasoning.

Some of the most fertile ideas in the prosecution of engineering works have come to me in the cramped shed while making some small part which has eluded my powers of accurate workmanship. Other ideas, which seemed brilliant during the day, mature in the same atmosphere and are prevented from becoming regrettable mistakes.

Get to Your Tools

So I say to others of us, " black-out " your workshop, fit up lights and get out your tools again on these so-called " dark nights " when meetings are difficult and other recreations impossible.

You will wonder why particularly I was glad to have purchased THE MODEL ENGINEER to-day. Because, firstly, I gave it up as an economy, and, secondly, I will admit frankly that I did not think it so good of late. To-day's issue, with its less flamboyant cover and first-class workshop articles, appeals to me as earlier issues did during other sterner days.

Before closing, I would also express tribute to the articles of never-failing interest and vitality which continue from your versatile contributor " L.B.S.C.," who first stimulated my interest in this fascinating and useful pastime.

Yours faithfully,

Otford. PETER F. GROVE.

Classification of Speed Boats (Class C)

DEAR SIR,—I am against changing the existing rules for the following reasons:—

(1) Myself, in common with a number of other 15 c.c. owners, would either have to build a new boat or skin weight off our present ones (neither of which I am inclined to do) to bring them within a 7 lb. limit. (2) At present it seems fair, to my mind, to quote c.c. in I.C. boats against total weight in steam boats, failing a $\frac{\text{B.T.U.}}{\text{Time}}$ system of classification for steam, i.e., speed of burning a certain amount of fuel. (3) According to recent correspondence, the man with a 15 c.c. boat over 7 lb. is only handicapping himself, so why worry?

I do not know if it has been suggested before, but something on the following lines may meet with the approval of those who want a change. It is, to run an event of all classes based on this formula $\text{X} = \frac{\text{Amount of fuel}}{\text{Distance}} \times$ m.p.h. (average total run), the winner being the boat returning the highest factor. Individuals could use their own fancy fuels, but only put into an empty tank, say, 40 cubic cms.; simple results might be so:—

$$\frac{2 \text{ miles}}{40} \times 20 \text{ m.p.h.} = 1. \quad \frac{2 \text{ miles}}{40} \times 30 \text{ m.p.h.} = 1.5.$$

$$\frac{2\frac{1}{2} \text{ miles}}{40} \times 30 \text{ m.p.h.} = 1.875.$$

I have used " miles " instead of " laps " for simplicity.

To all concerned, may we soon be trying conclusions again.

Yours faithfully,

Enfield. " XYZ "

Model Speed Boat Classification

DEAR SIR,—I have read with interest the letters published referring to Mr. Westbury's article on "Model Speedboat Classifications." I am not at all clear why weight restrictions as well as capacity limits are imposed in the case of I.C. engines. Weight imposes its own restrictions, as the engine has to push it round the pole. Until the b.h.p. of various engines installed in boats is known, I do not see that comparisons can be made between competitors' boats.

My own boat, *'Ark*, was made from designs published in the "M.E." and turns the scale at about 8 lb. 4 oz., and while I could save quite a bit by making a more flimsy job of the hull, I cannot knock much off the engine. No doubt, if I live long enough, I shall make a complete boat weighing less than 7 lb., but it is by no means certain that it will achieve great speeds on this account. I shall need to learn something about getting the maximum power from the 15 c.c. capacity allowed. My engine produces 0.48 b.h.p. at 5,600 r.p.m., which is not at all good, and I am quite sure that reducing the weight to 7 lb. or under would not make the boat do 35 m.p.h.

Yours faithfully,

Salisbury. H. SCAMELL.

A First Attempt

DEAR SIR,—I am sending you a photo of my first attempt in loco. construction. Although I am a member of the S.M.E.E., I am a "lone-hand," for the model was built in my workshop at the Grand Hotel, Penmaenmawr, North Wales. My workshop consists of a $3\frac{1}{2}''$ long-bed B.G. S.C. lathe, a "Pool" milling machine, a $\frac{1}{4}''$ sensitive precision drill, a $\frac{1}{4}''$ electric hand drill, and a double-ended grinder. Also, the usual bench tools.

The boiler was built up with a 6-pint blowlamp and an oxy-acetylene outfit borrowed for the occasion.

The most difficult part of the whole job, which took nearly two years of my spare time, was lagging the boiler, especially round the throat-plate.

I have also built a double bogie ball-bearing truck, using Messrs. Bond's castings, and it was my intention to construct a continuous elevated track 200 yards long in the grounds of the hotel, but unfortunately the war knocked the scheme on the head.

Although I have had the loco. under steam, running on the floor in a long corridor, I have not yet had the opportunity of trying her out on a track.

I would like to obtain the name and address of some kind enthusiast with a $3\frac{1}{2}''$ gauge track, not more than say 30 miles from Leamington, who would let me have a run? I have been looking forward so much to the day when I could drive my first loco.

Yours faithfully,

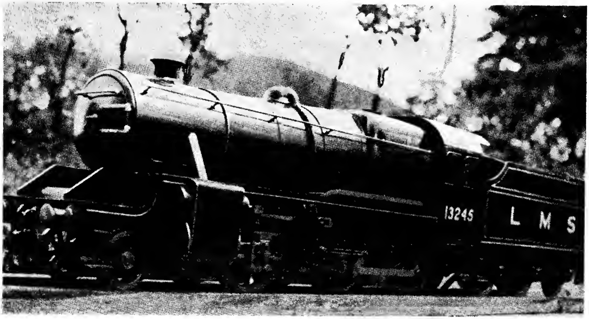
Leamington Spa. A. BRAGG-SMITH.

"Miss Ten-to-Eight"

DEAR SIR,—I would like to point out that the N.E.R. "R 1's" had their smokeboxes on saddles when they first came out. I do not know if they still have, but they probably do. In the original arrangement, the front of the smokebox and saddle were flush with each other, with only the radius of the front plate projecting beyond the saddle. I do not know if "L.B.S.C." has any particular reason to depart from the prototype design, but his arrangement, of course, means a good deal more work.

Yours faithfully,

Bexhill-on-Sea. C. M. KEILLER.



Mr. A. Bragg-Smith's $\frac{3}{4}$ in. scale coal-fired locomotive "Princess Marina."